

Internet of Things (IoT): Systems & Security

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What is the* IoT?

- Break into groups of around 3-6 and discuss
- Answer:
 - What is IoT?
 - What is *not* IoT?
 - Why is the IoT interesting?

* Though “the IoT” is correct, I’ll often simplify as “IoT”

Embedded Systems

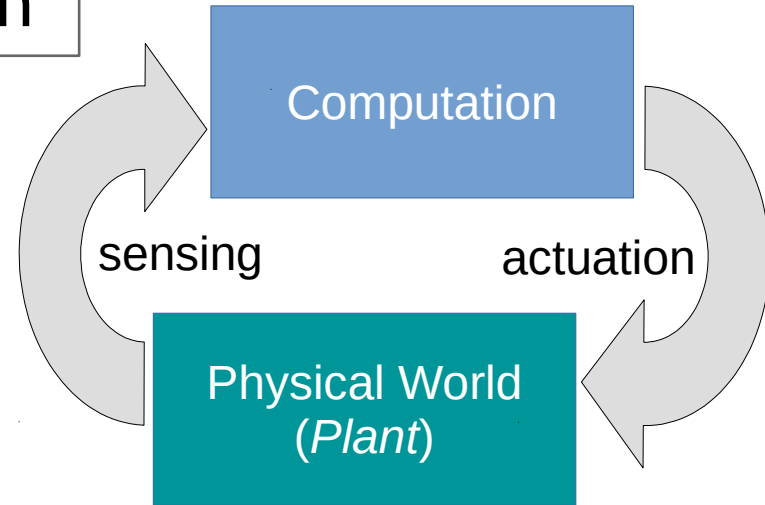
- Same group:
 - What are embedded systems?
 - How do they differ from “normal” computers?
 - How are they related to IoT?

Cloud Systems

- Same group
 - What is the cloud (the *idea*, not an implementation like EC2)?
 - Why is it useful in general?
 - How is it related to IoT?

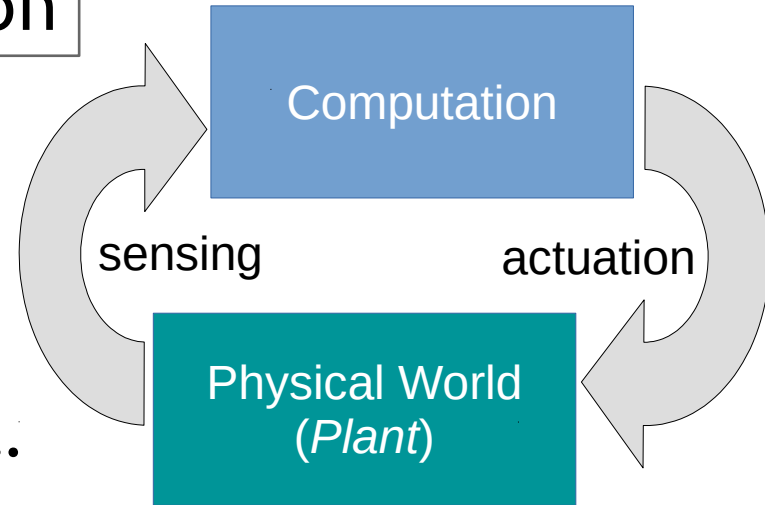
Embedded Systems

- Computers that interact with physical world
 - Sensors + actuators + computation
- Replace mechanical w/ digital
 - Microwaves, toys
 - Cars, airplanes



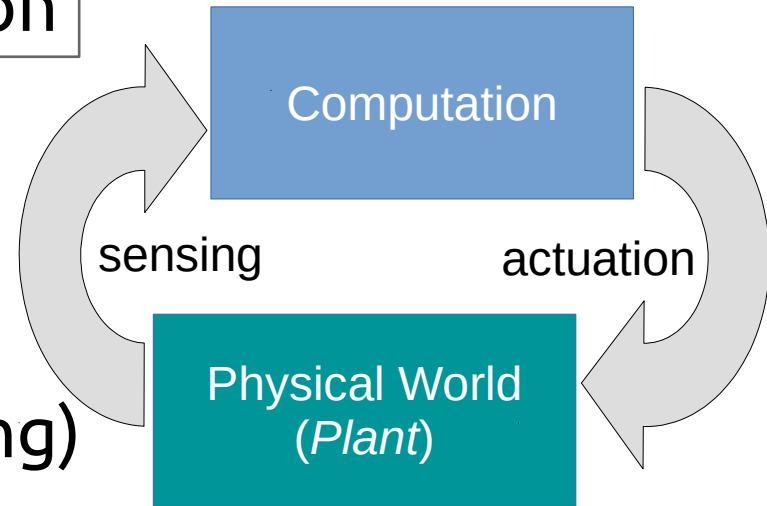
Embedded Systems

- Computers that interact with physical world
 - Sensors + actuators + computation
- Sensors
 - Visual/audio: Camera/mic
 - Environment: temp, barometer, ...
 - Position: IMU/Gyro
 - Range: LIDAR, infrared/ultrasonic



Embedded Systems

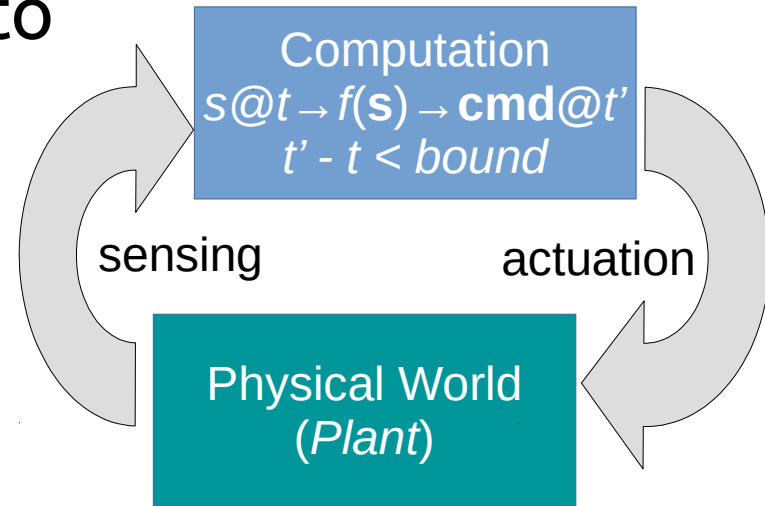
- Computers that interact with physical world
 - Sensors + actuators + computation
- Actuators
 - DC motors (high RPM)
 - Servo/Stepper motors (positioning)
 - Human: Screens/speakers
 - Environment: lights, HVAC



Real-Time/Cyber-Physical Systems

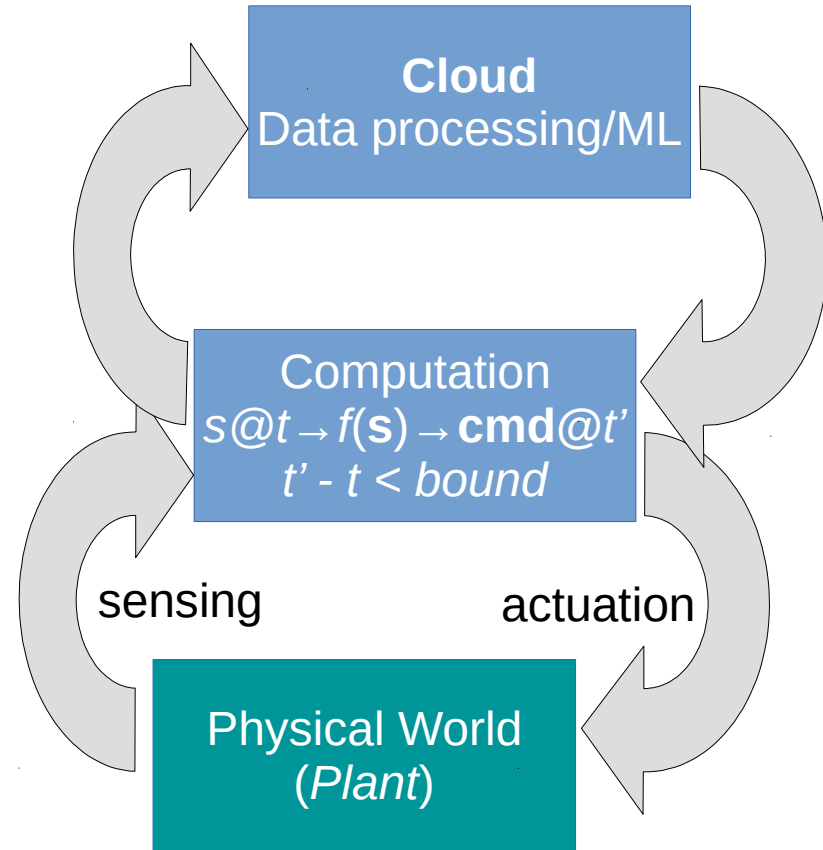
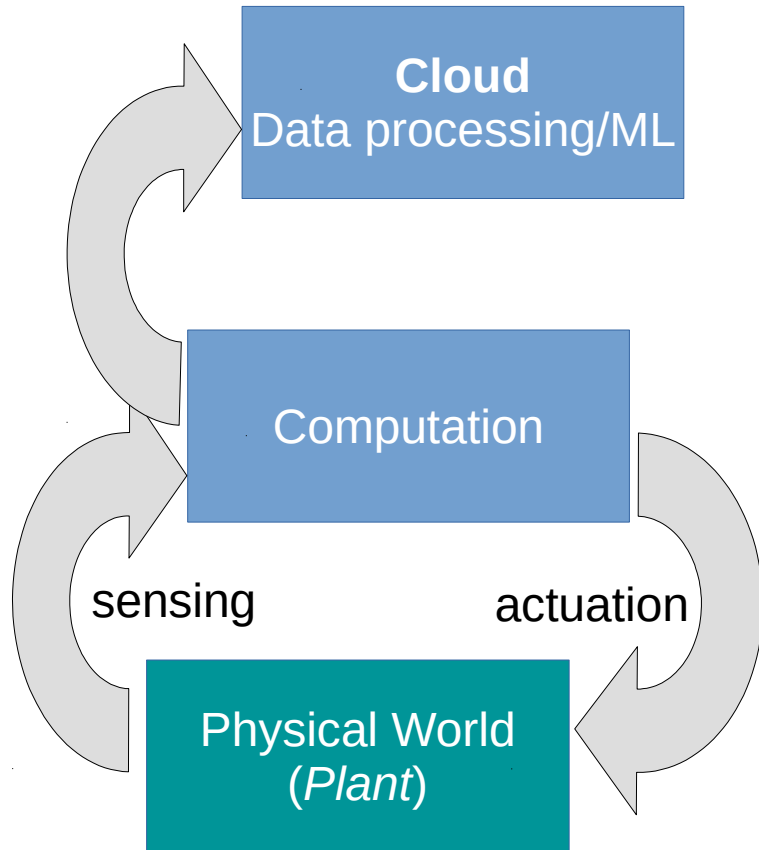
- **Embedded systems + deadlines**

- The computation must adhere to the timing constraints of the physical world
- Send command to actuator within a **bounded time** from receiving sensor information
- We don't write code thinking about time; *how do engineers program real-time systems???*



IoT Systems

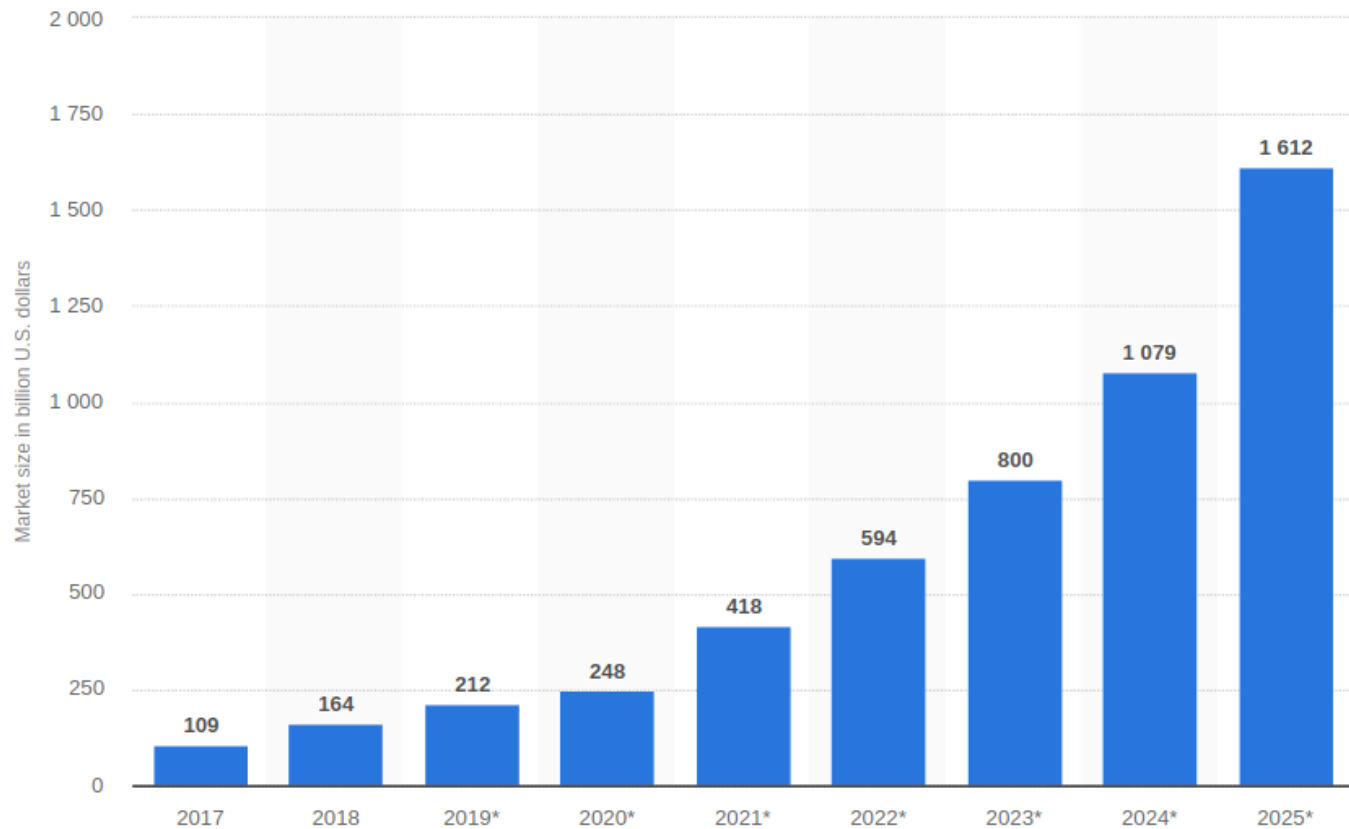
Embedded/RT systems +
network



This class: How do we *implement/program* the IoT

- System design
 - Embedded device
 - Cloud system
- Controlled coordination
- Collaborative: Device + cloud!

Why IoT: Market size (in Bn \$)

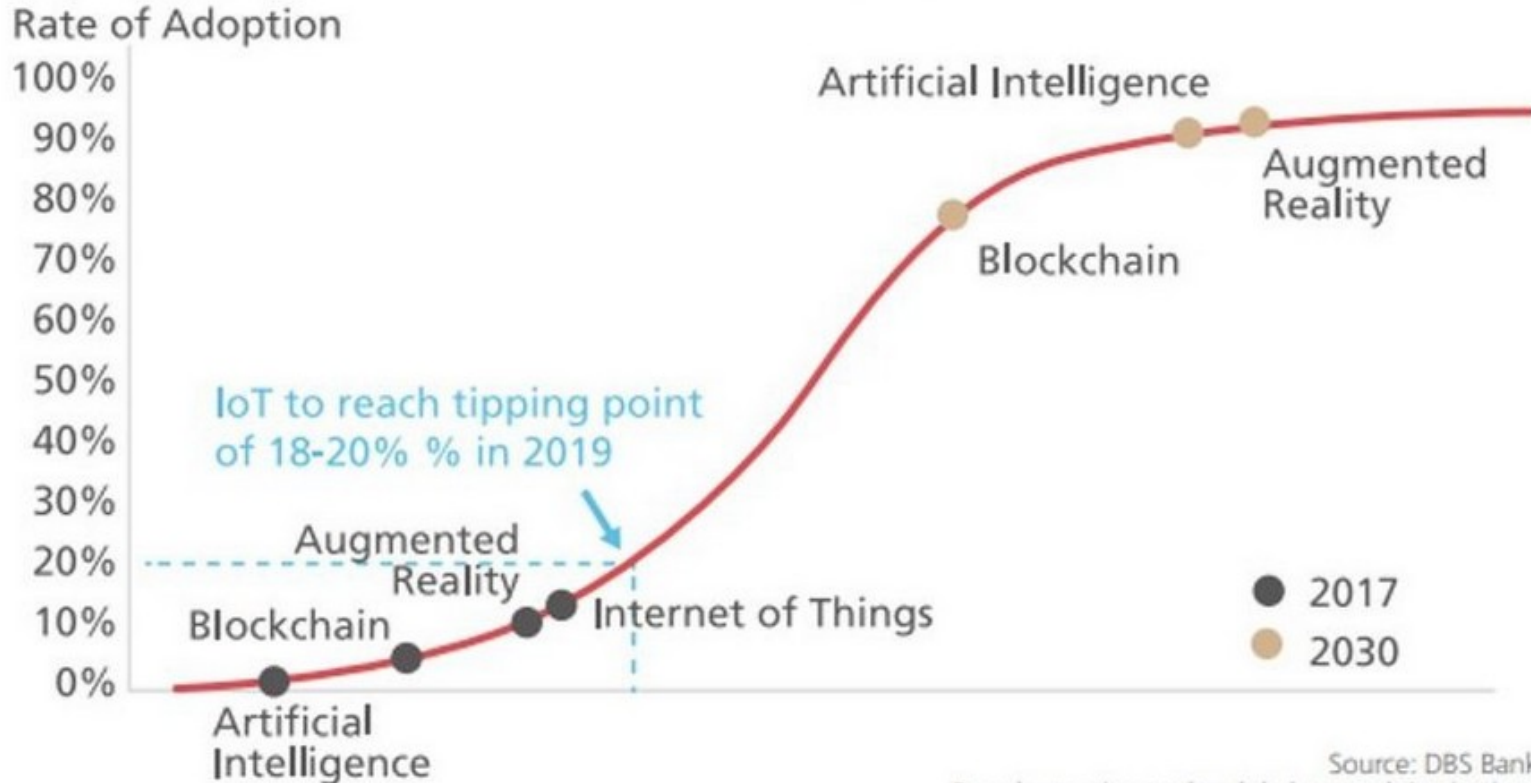


IoT: so many versions of *hype*

- Smart X for X in
 - House, building, city
- Cyber-Physical Systems
- Industry 4.0
- Edge Computing
- Cognitive computing

...too much hype

IoT adoption to approach 100% over the next 10 years



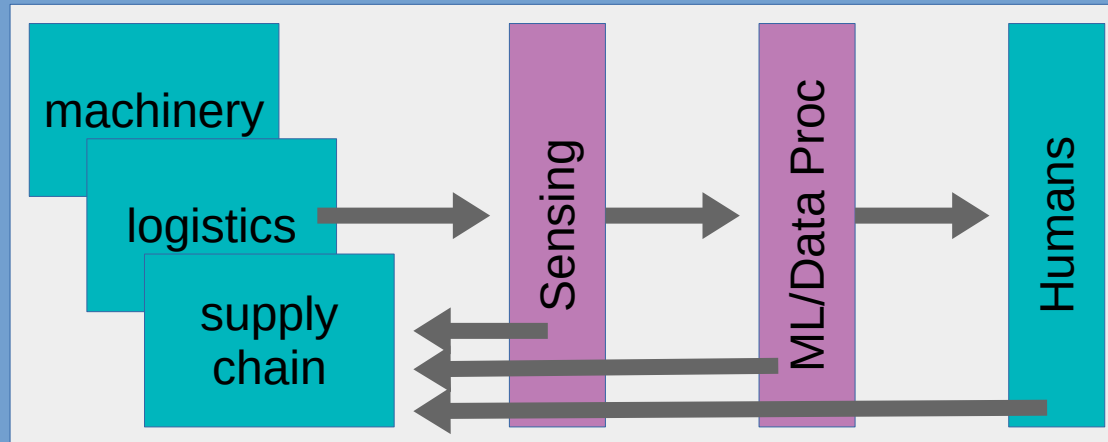
Source: DBS Bank
Based on estimates by global research institutions

Industry 4.0

- Industry 1.0 – [1760-1840]
 - hand production → machines
- Industry 2.0 – “industrial revolution” [1870-1914]
 - Production lines, electrification, efficient supply chains (railroads)
 - Mass unemployment
- Industry 3.0 – “digital revolution” late 1900s
 - Internet & computers for efficient production
 - More movement away from human labor – “manufacturing is dead”

Industry 4.0

- Industry 4.0 – Now-ish? Germany: 10 years ago
 - Pervasive industrial sensing/monitoring
 - Data processing and intelligence generation
 - Self adaptation



More: Jeremy Rifkin – The Third Industrial Revolution

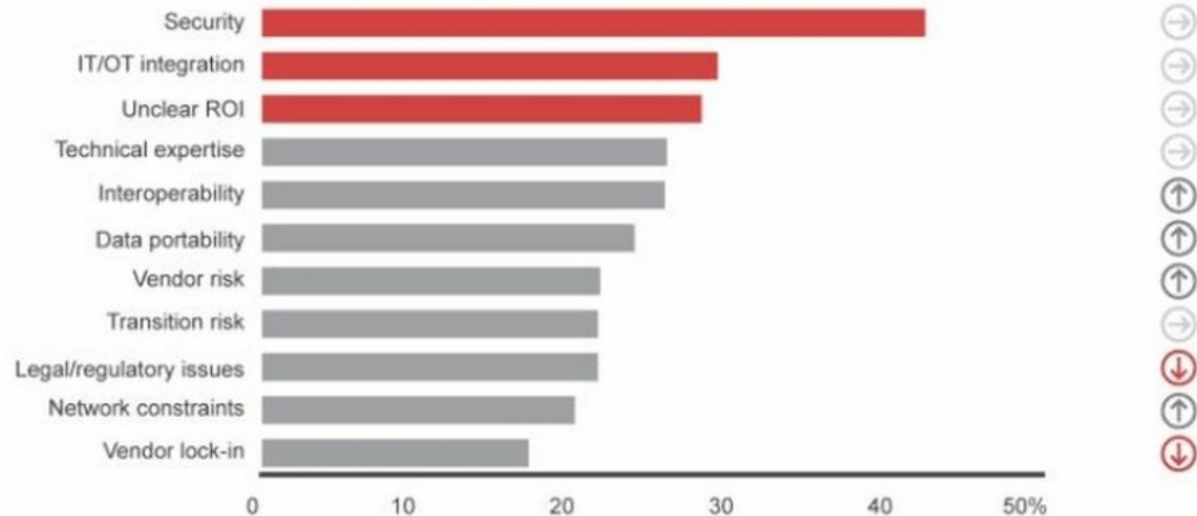
Barriers to IoT adoption

Vendors need to address customer barriers—especially security, integration and unclear returns on investment

What are the most significant barriers limiting your adoption of IoT/analytics solutions?

Change since 2016

Percentage of respondents (top three barriers)



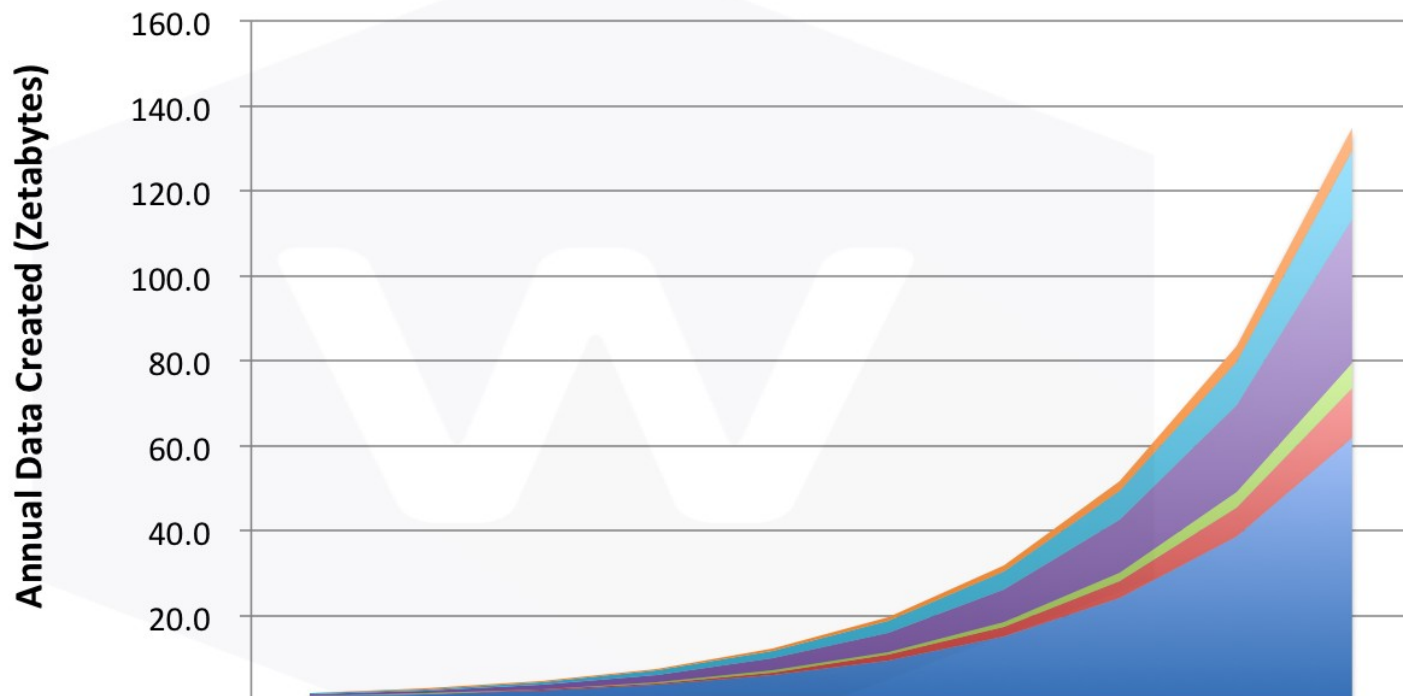
Sources: Bain IoT customer survey, 2016 (n=533); Bain IoT customer survey, 2018 (n=627); market participant interviews

This class: How can we *secure* IoT?

- Embedded system/device/node security
 - Secure OSes
 - Secure execution environments
- Secure Coordination
 - Authentication
 - Communication mechanisms

Data Creation

All Data Created by Category 2011-2020 (Zetabytes)



	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Consumer Images, Voice & Video	0.1	0.2	0.3	0.4	0.6	1.0	1.5	2.3	3.5	5.4
Entertainment & Social Media	0.3	0.5	0.7	1.1	1.7	2.7	4.3	6.7	10.4	16.2
Data Processing	0.4	0.6	1.0	1.7	2.8	4.6	7.6	12.5	20.5	33.7
Medical	0.0	0.1	0.1	0.2	0.4	0.7	1.2	2.0	3.5	6.1
Internet of Things	0.1	0.2	0.3	0.5	0.8	1.4	2.3	4.0	6.8	11.5
Surveillance	0.9	1.4	2.3	3.7	5.9	9.5	15.1	24.2	38.8	62.0

Source: © Wikibon 2015, based on Wikibon 2013 Projections

Data Creation

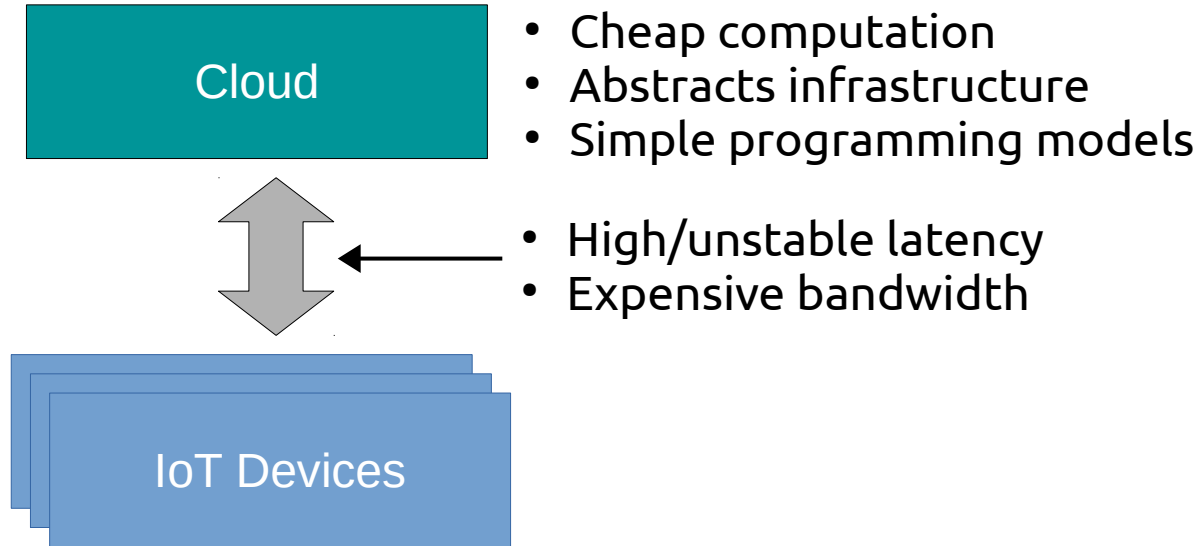
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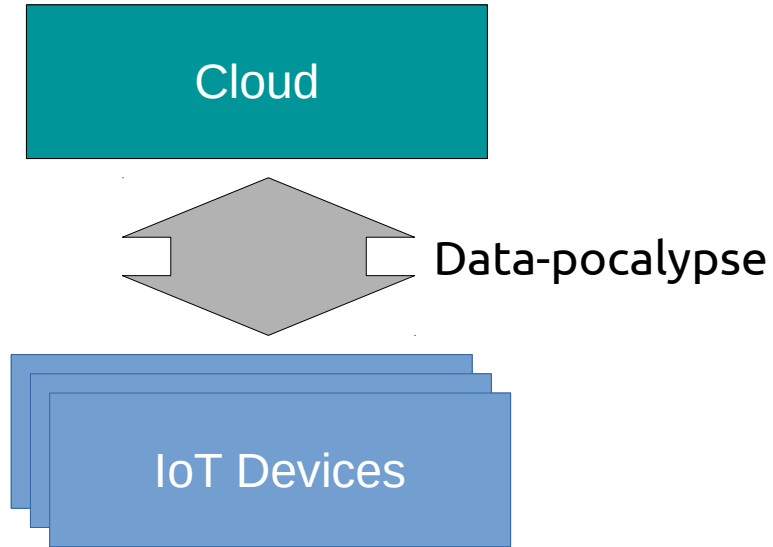
Cisco: by 2020, more than 4.7 zetabytes will pass through the Internet

A significant slice will be from M2M comm.

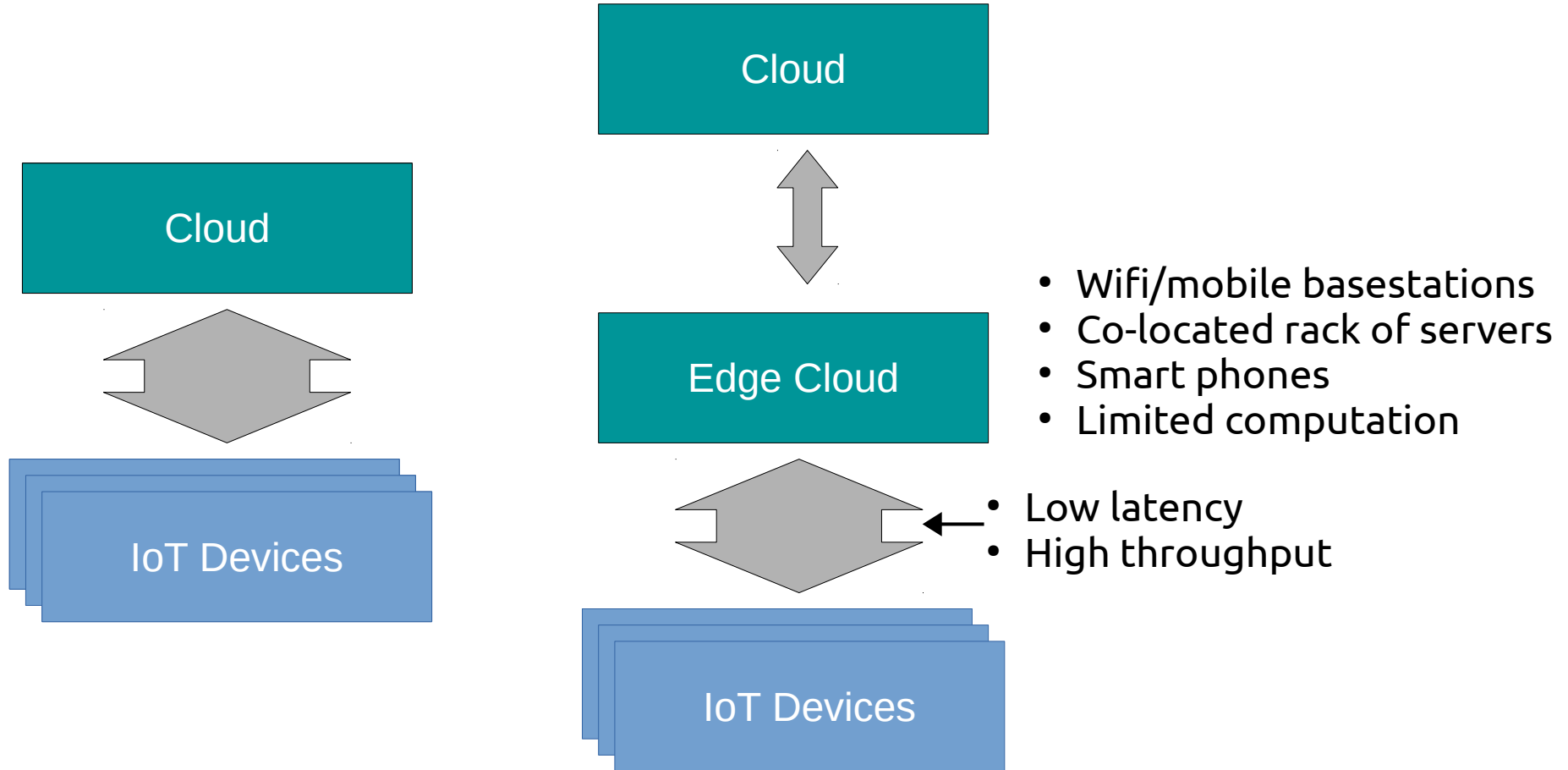
Edge Computing



Edge Computing



Edge Computing



Edge Computing

Enabling Technology: 5G

- Mobile with
- Gb/s & **1ms round-trip**

Example Uses:

- Drone/quad-copter control
- AV global situational awareness
- Data filtering/processing (Surveillance)

CI

IoT

base stations
stack of servers
es
putation

ut

This class

Where *computation* meets the *physical world*

- How do we
 - Design these systems?
 - Program these systems?
 - Secure these systems?
 - Conquer the software stacks of these systems?
- What is the cutting edge research?

Logistics

- Class online presence
 - Webpage:
google “gabe parmer” → teaching tab → this class
 - Piazza
 - Github org **gwu-iot** – linked from Piazza
 - gwu-iot/collaboration → most class material
 - *Mutable* class policies by github Pull Request (PR)

Class Structure

- $\frac{1}{4}$ Instruction
 - Me and guest speakers
- $\frac{3}{4}$ Discussion/analysis
 - Reading/presenting research papers
- Work
 - Weekly: reading papers, critiquing on github
 - 1-2 times semester: lead the discussion of a paper
 - Semester-long project...

Project

- Look through the inspirational projects
 - Interactive art installation
 - AV control via smart environment
 - PR: add one!
- Next class: brainstorm 3 project ideas
- Groups
 - IoT is collaborative
 - Exceptions are possible